

Influence of Glaciers on Coastal Marine Ecology

Yumi Arimitsu

U.S. Geological Survey Alaska Science Center

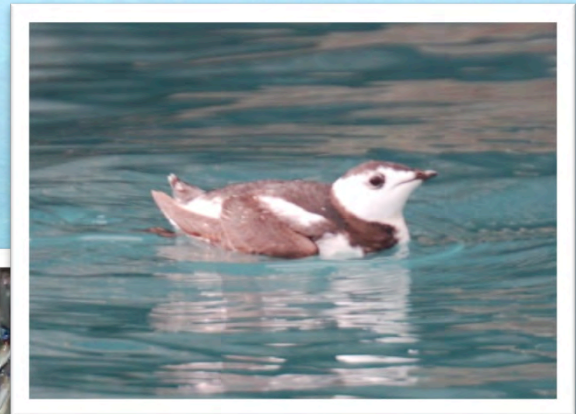
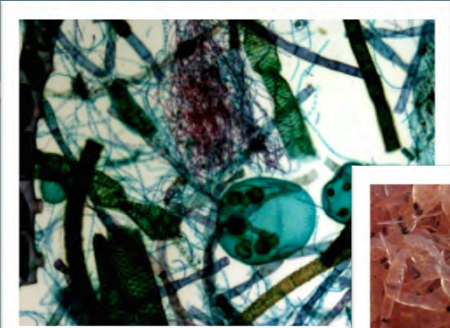
Juneau AK

Glacier Workshop Mar 5, 2013

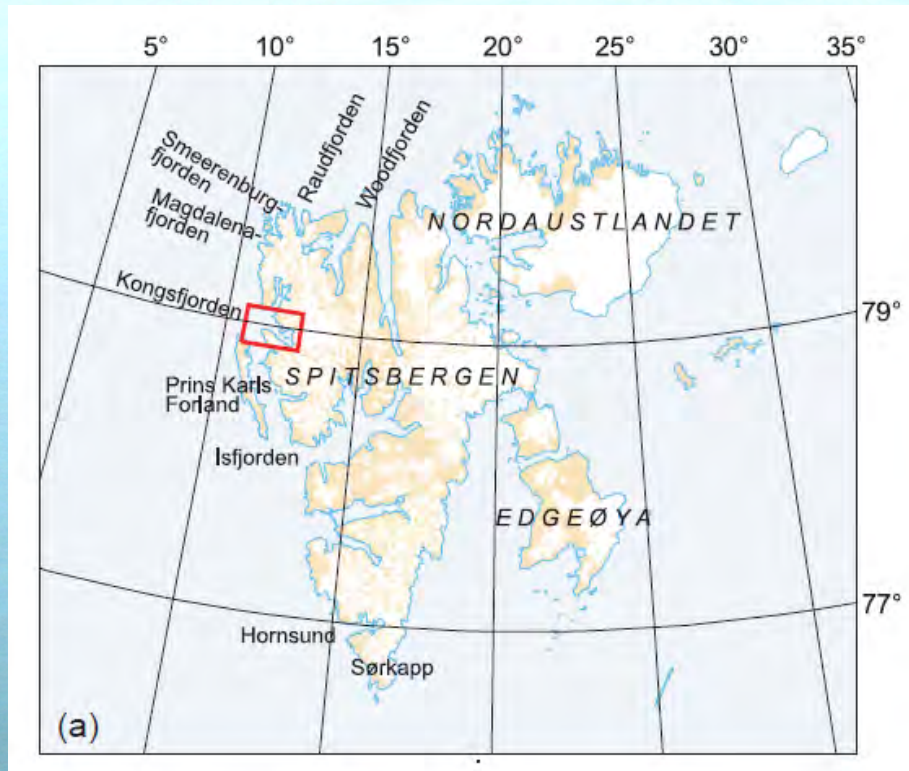
Overview

How do glaciers affect coastal ecosystems?

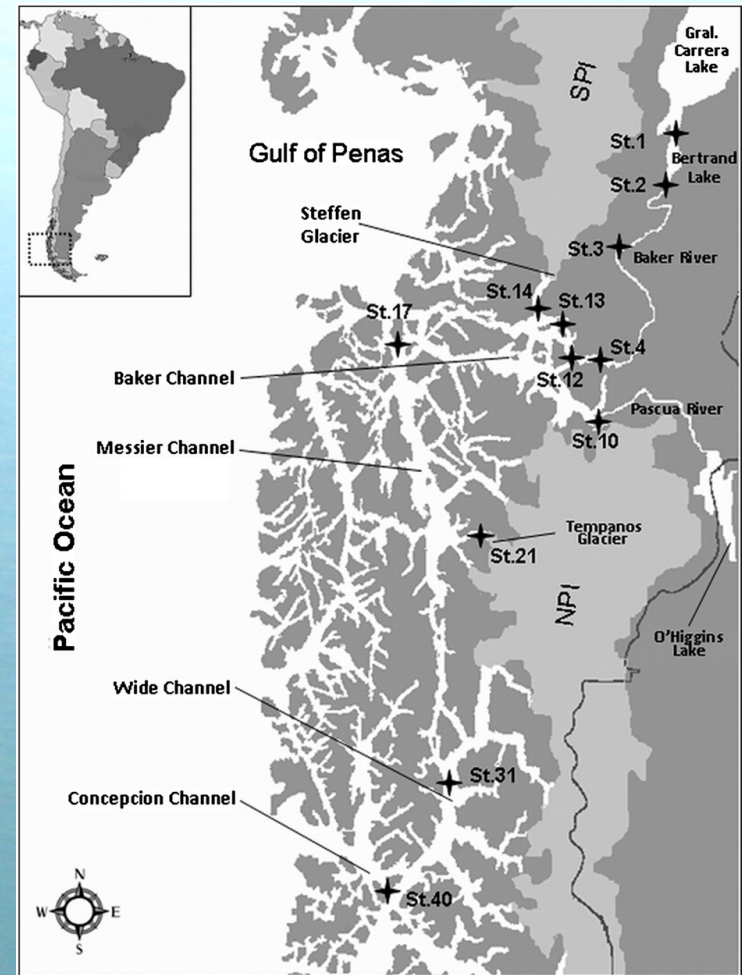
- Literature
- USGS Marine Ecology Project



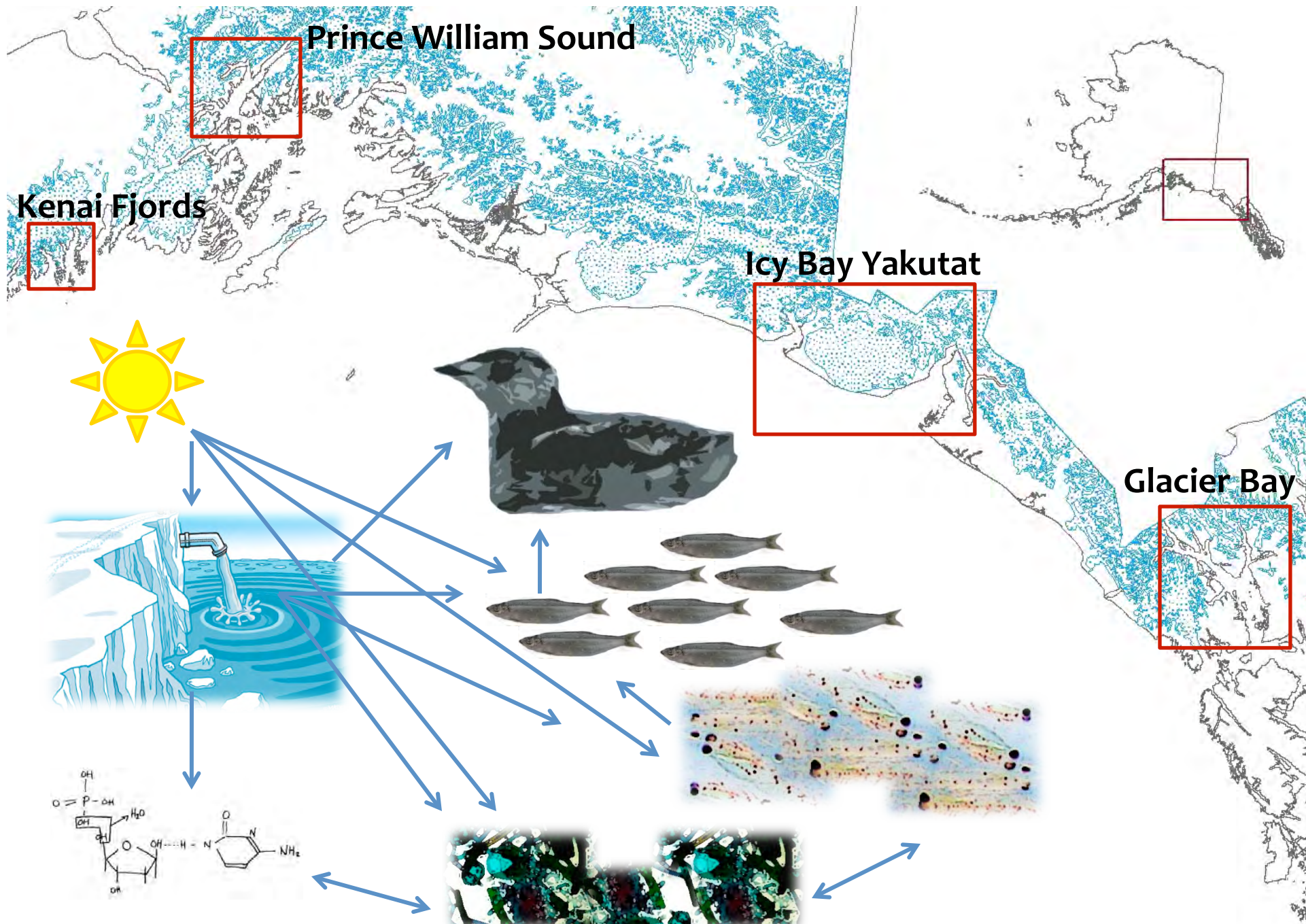
Previous Work




Hop *et al.* 2002. Polar Research 21: 167 - 208




Vargas *et al.* 2011 Continental Shelf Research 31: 187 - 201




Phytoplankton

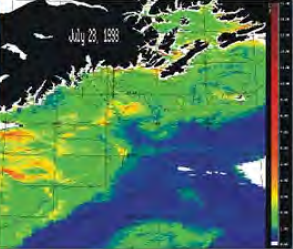


SEWARD LINE






HOME



RESEARCH




EDUCATION

ABOUT US

Home

Gaining an understanding of the coastal Gulf of Alaska ecosystem through long-term observations



The Seward Line is a long-term observation program (LTOP) undertaken from 1998-2004 by the Northeast Pacific GLOBEC program, and continued from 2005-2009 by the North Pacific Research Board. It is now funded by a consortium of NPRB, AOOS, NOAA and EVOS.

The purpose of this research is to develop an understanding of the response of this marine ecosystem to climate variability.






Toward this end, the Seward Line cruises on the Gulf of Alaska shelf determine the physical and chemical oceanographic structure, the primary production and the distribution and abundance of zooplankton. We then examine the seasonal and inter-annual variations in these measurements. At present, cruises are conducted each spring (May) and late summer (early September).

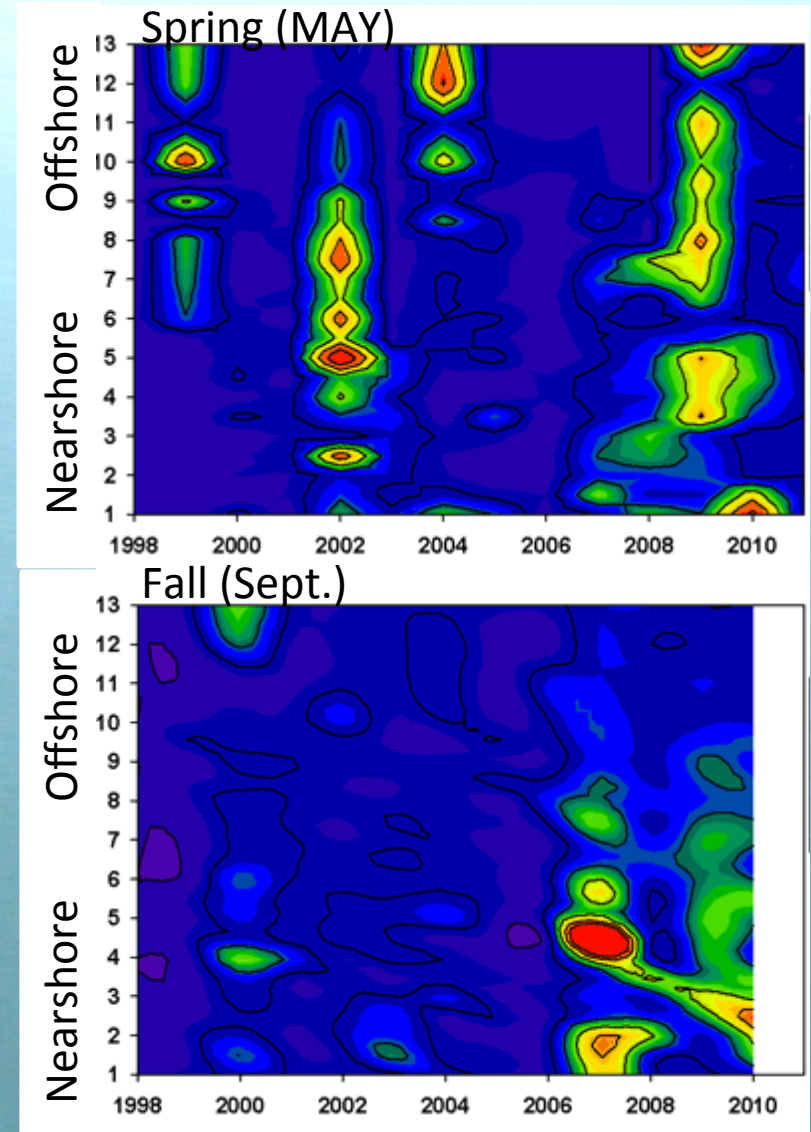
Spring 2011 status

- Spring melt/run-off: **LOW** (Slightly delayed)
- Water temperatures: **COOL** (Slightly)
- Spring phytoplankton bloom: **Just BEGINNING** (DELAYED)
- Spring zooplankton growth: **SLOW**
- Spring zooplankton number: Slightly **BELOW AVERAGE**

Summer 2011 status

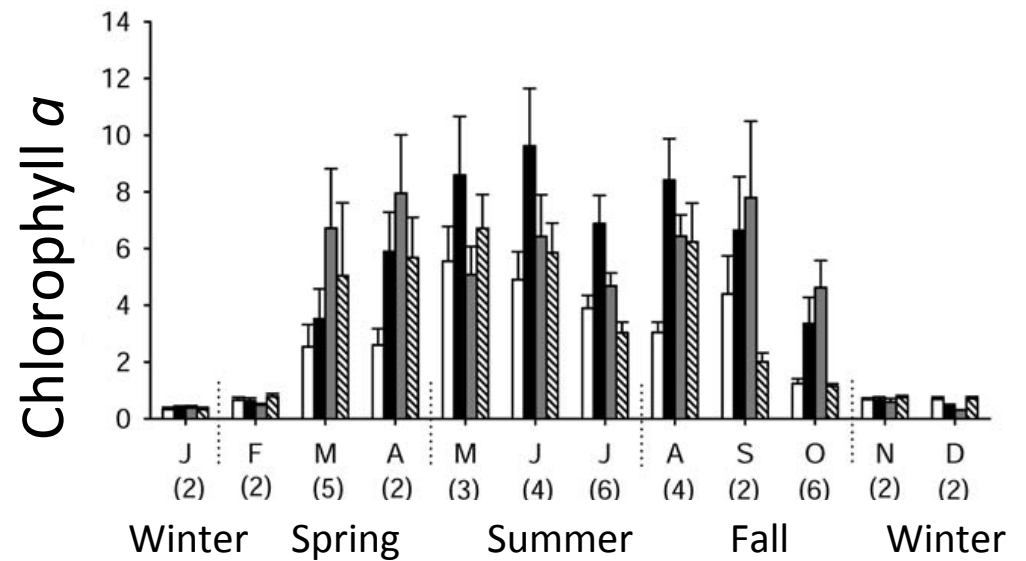
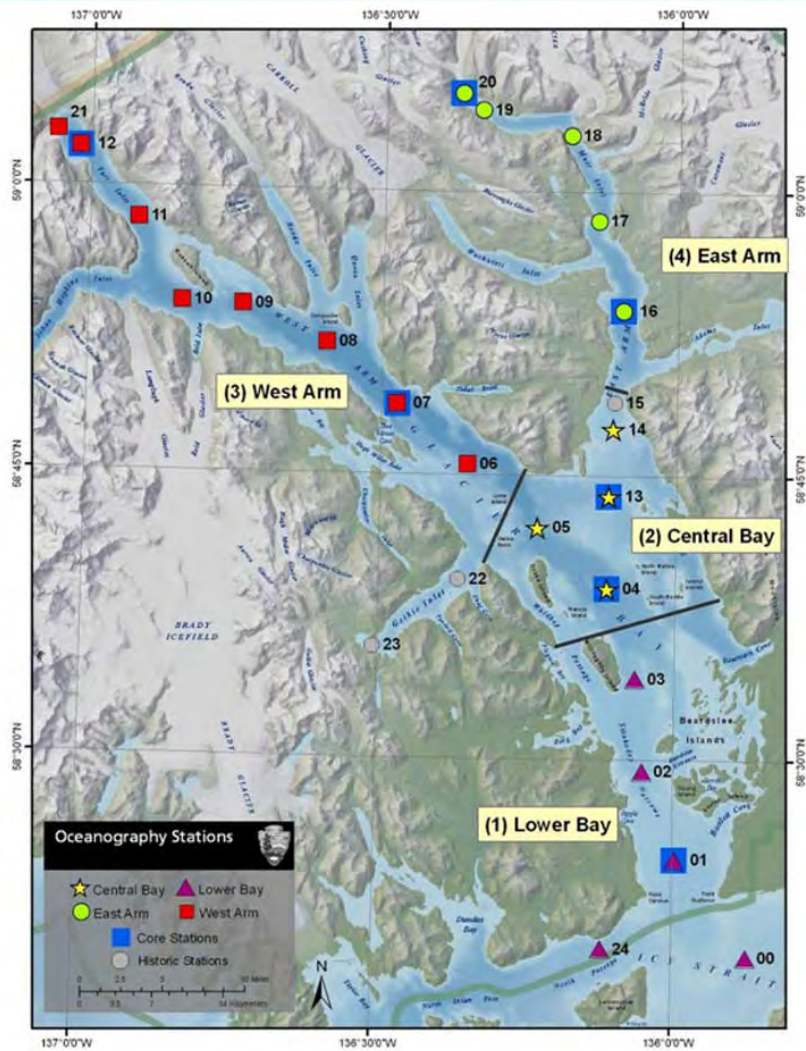
- Water temperatures: **AVERAGE**
- Phytoplankton: **AVERAGE**
- Zooplankton abundance: **Above NORMAL**
- Southern Zooplankton Species: **Salps remain common**



<http://www.sfos.uaf.edu/sewardline/>

Phytoplankton



Etherington *et al.* 2007

More information and data available at: http://science.nature.nps.gov/im/units/sean/OC_Main.aspx

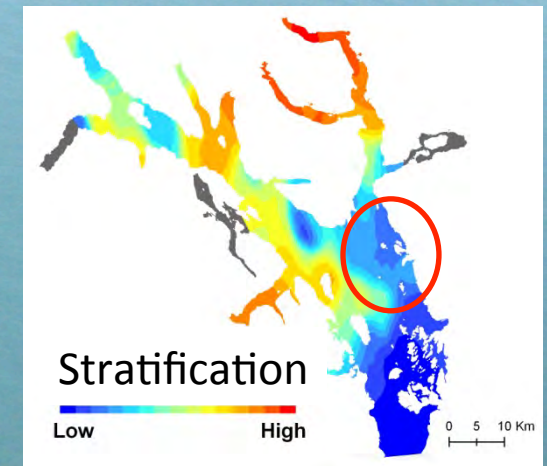
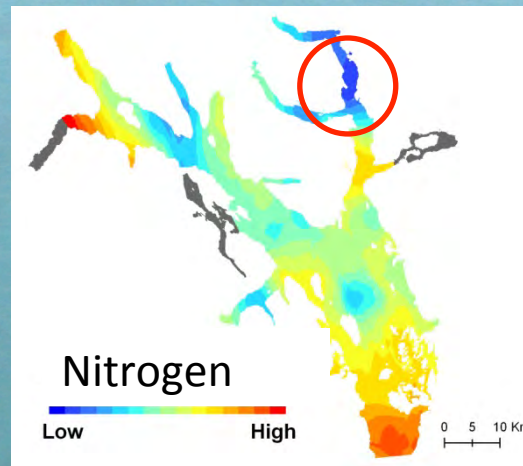
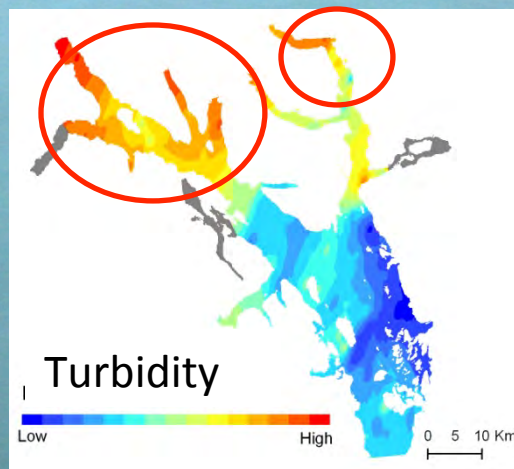
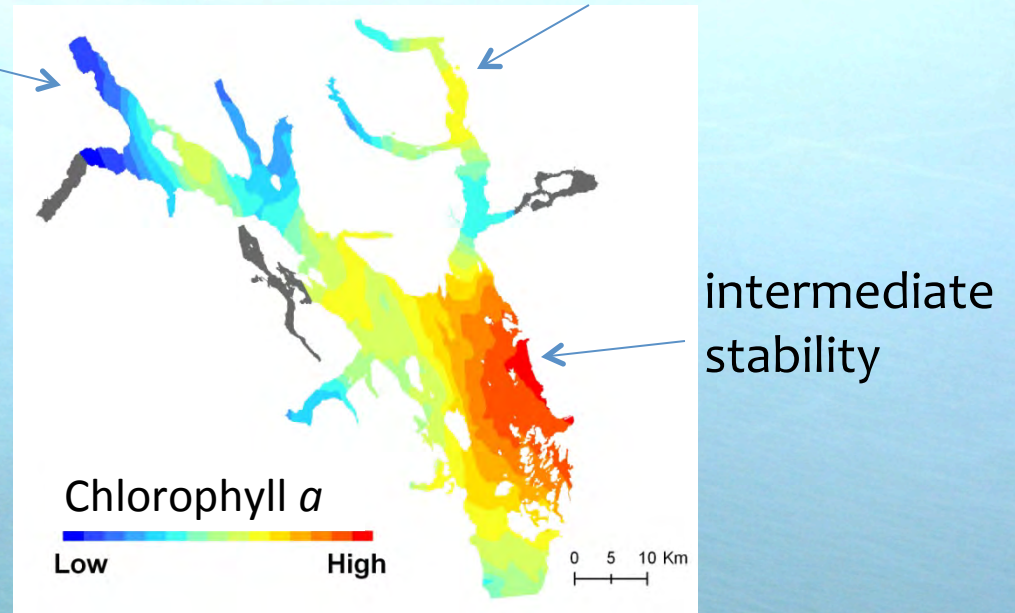
Phytoplankton

light limited

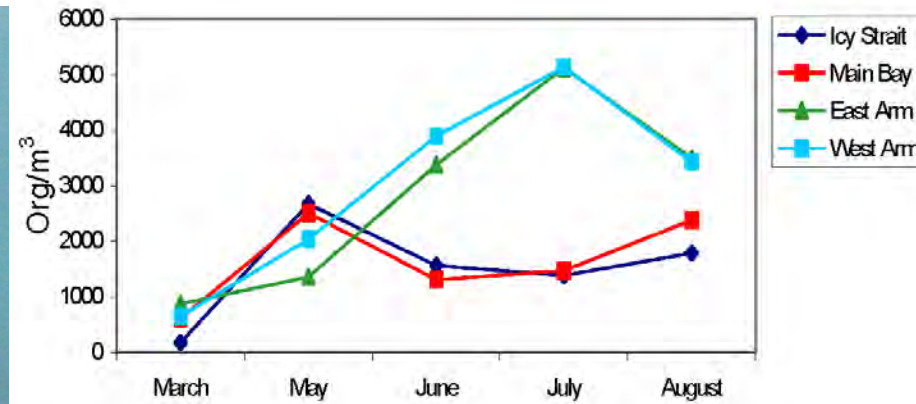
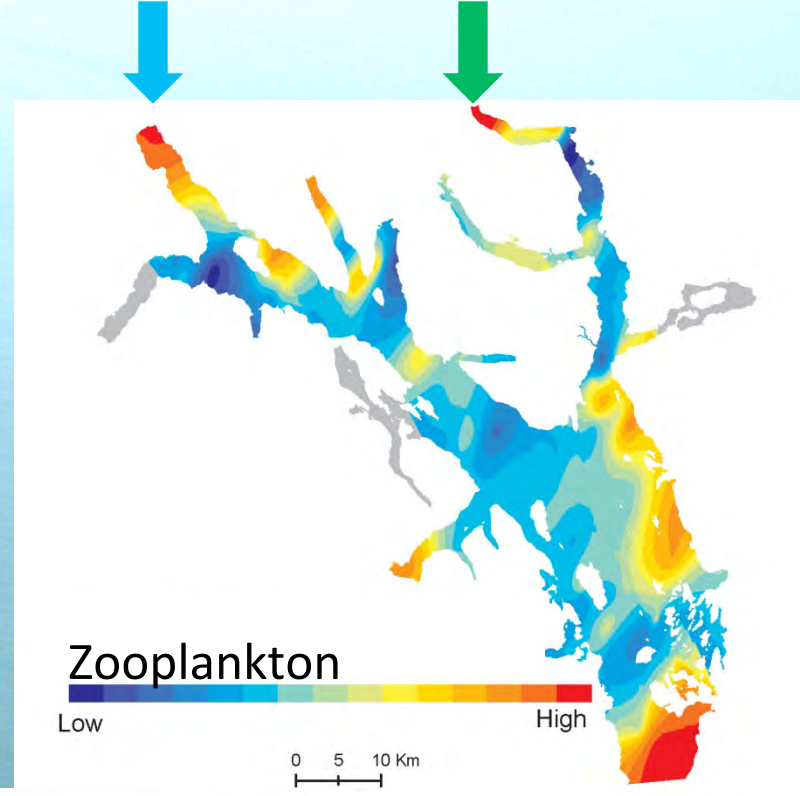
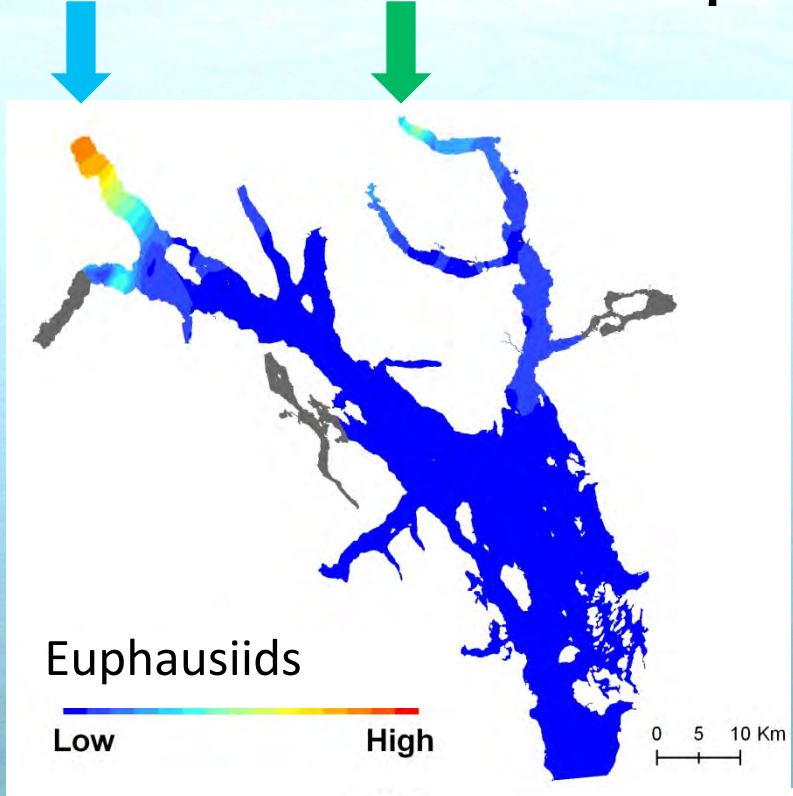
nutrient draw down

Optimum stability window:

Primary production is highest in balance with water column stability, light and nutrients (Gargett 1997)



Zooplankton



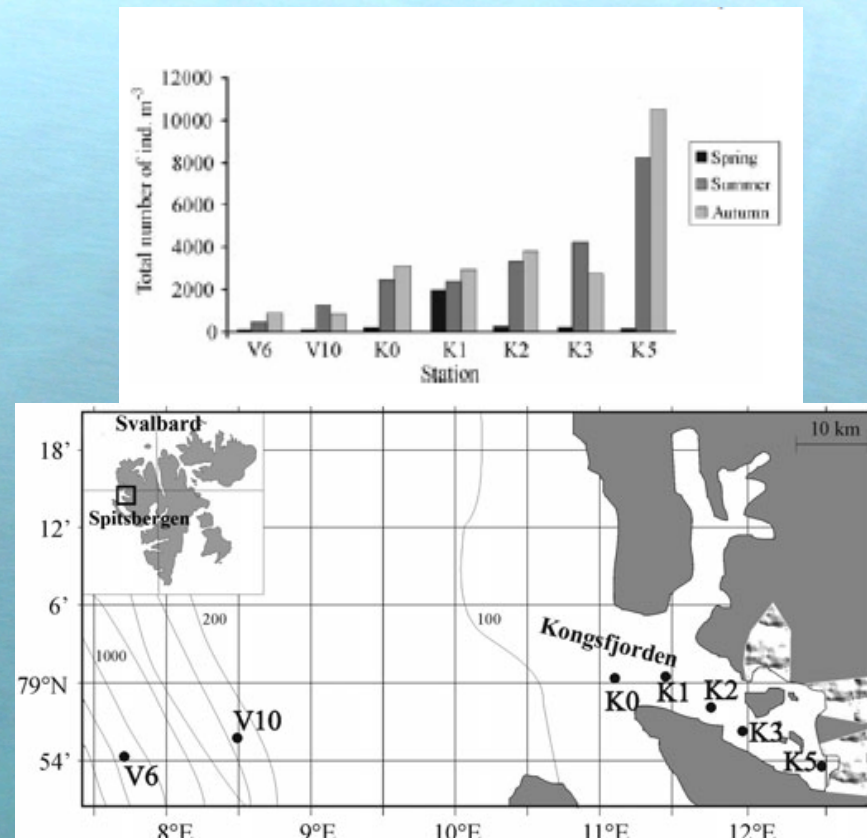
Robards *et al.* 2003

Zooplankton in Svalbard Fjords

High abundance of zooplankton in the inner basin

Krill and copepods are concentrated by advection into the fjords

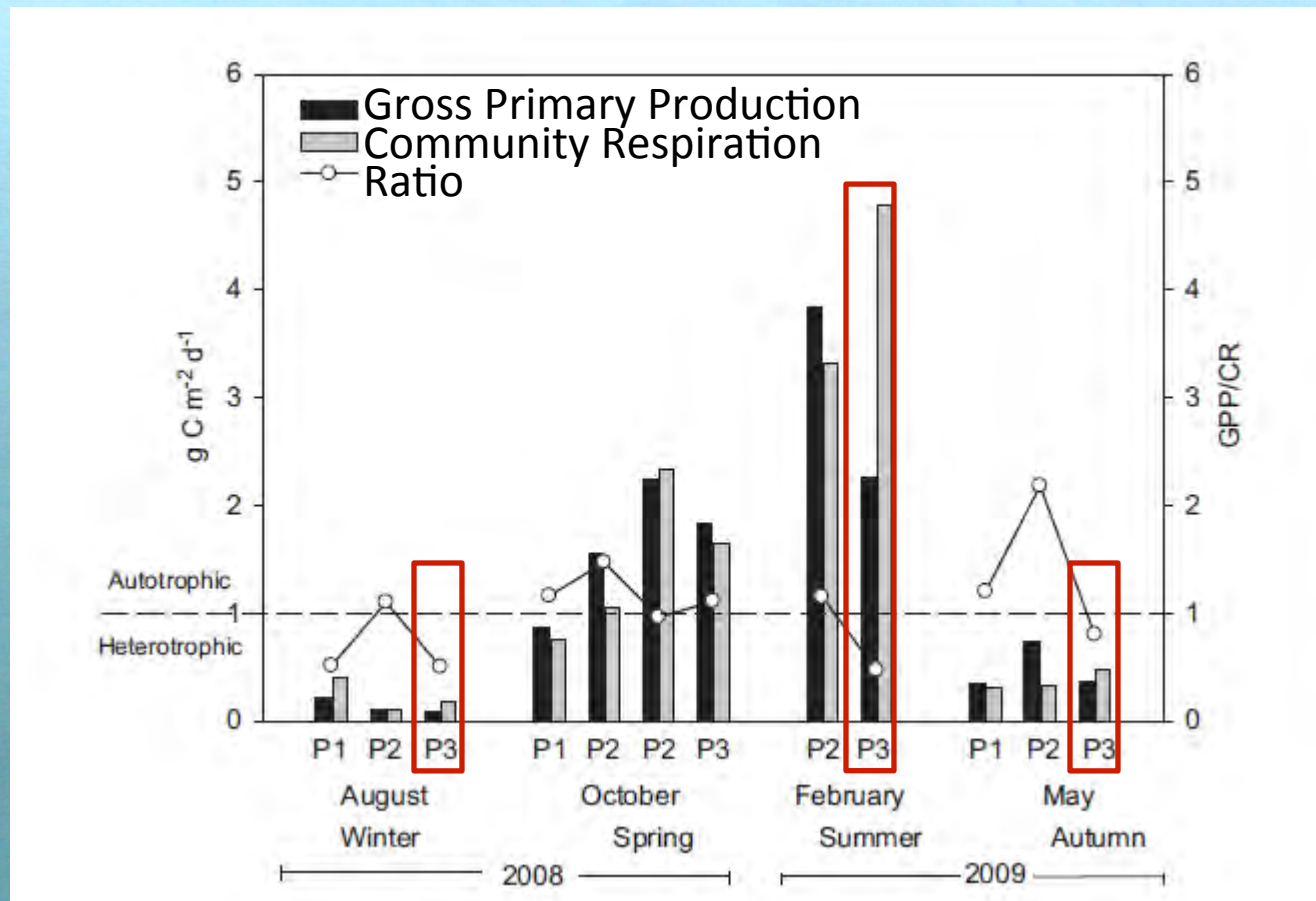
Entrapped by estuarine circulation



Weslawski *et al.* 2000, Walkusz *et al.* 2009

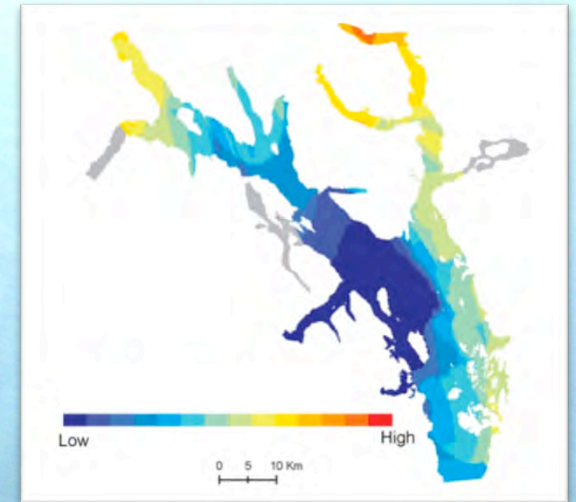
Auto- vs. Heterotrophic Production in Chilean Fjords

- **Where phytoplankton is limited by light, microbial food webs are important for carbon export**
- Heterotrophic protists and mesozooplankton mediate the transfer of carbon to higher trophic levels

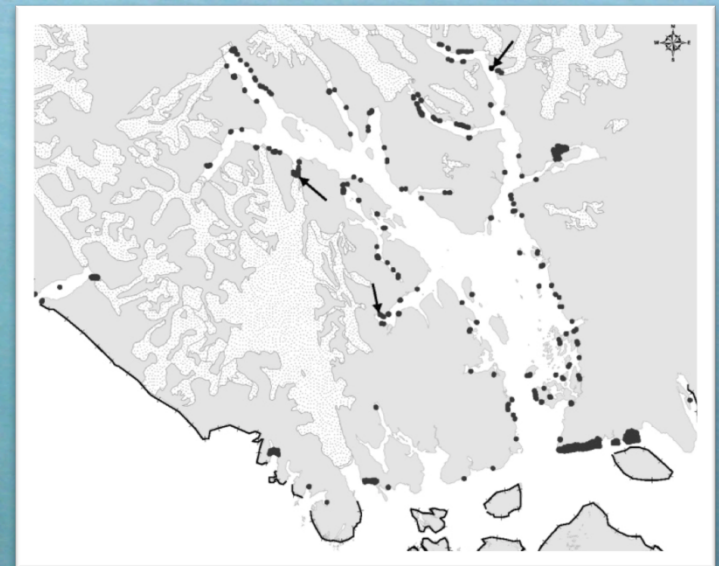


Capelin Spawning Dynamics

Glacier fjords are cold water refugia for spawning capelin during spring and summer

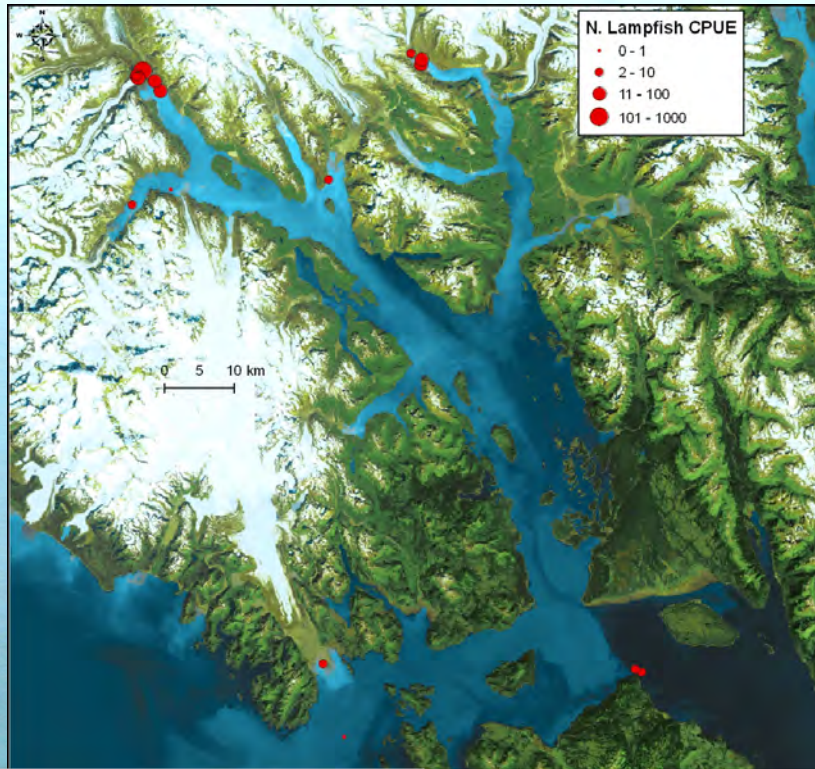


Capelin distribution

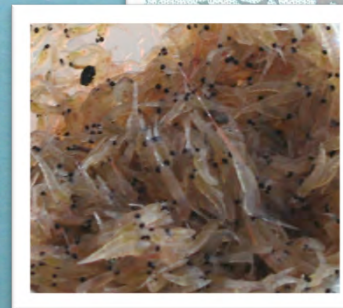
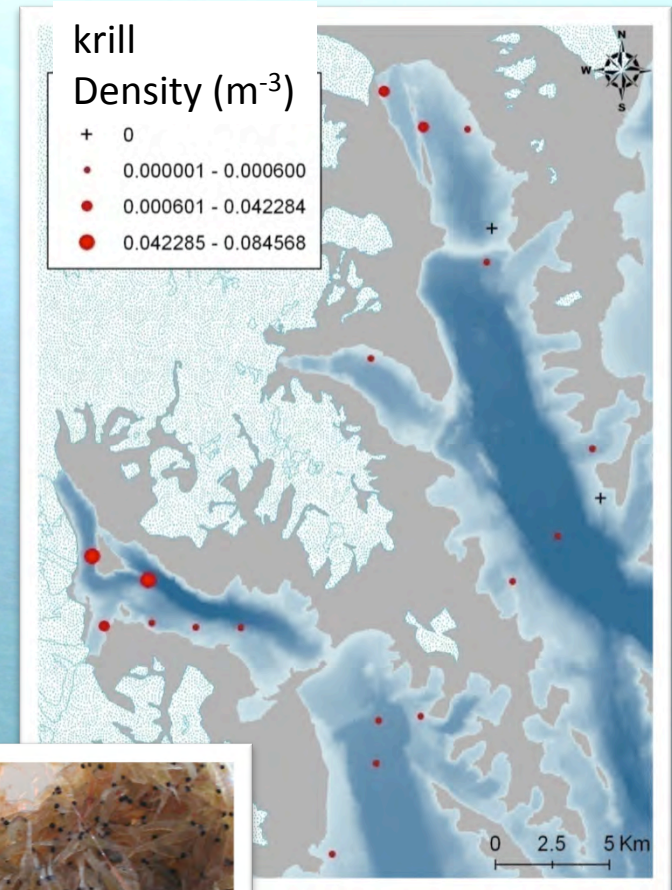


Potential spawning habitat

Mesopelagic Species



Abookire *et al.* 2002



vertical migration is suppressed in
turbid glacier plume

Arimitsu *et al.* 2012

Invertebrates

Intertidal boulder transplant study (Sharman *et al.* 1990):

- Species richness decreased after the first winter when transplanted from lower bay to glacier sites (sediment, ice-scour)

Deep-water “emergent” corals at shallow depths (Stone *et al.* 2007, Waller *et al.* 2011)

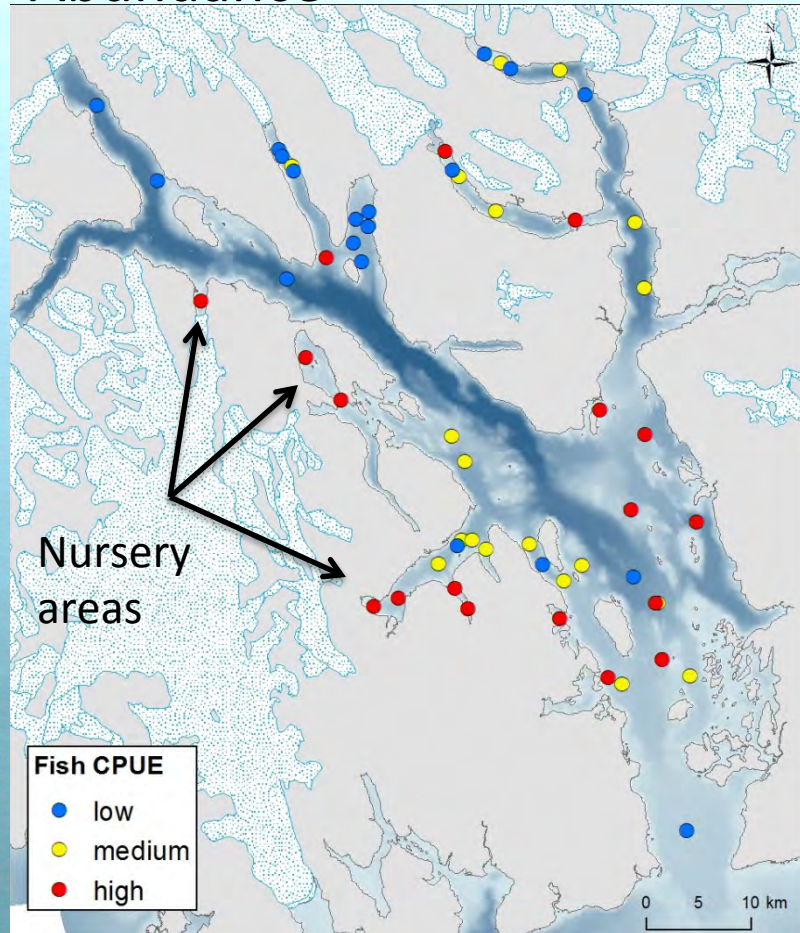
- Red tree coral grow in dense thickets in Tracey Arm and Endicott Bay, and Glacier Bay at ~18 m depth
- typical depths for this species: 150 -900 m



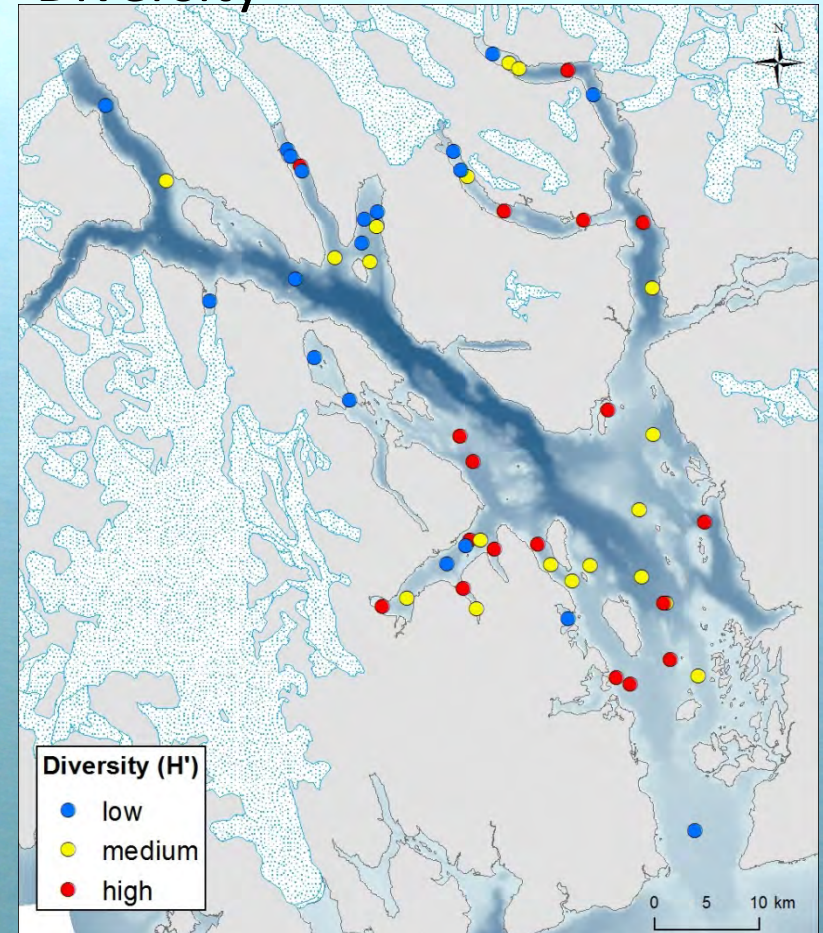
Bob Stone

Benthic Fish

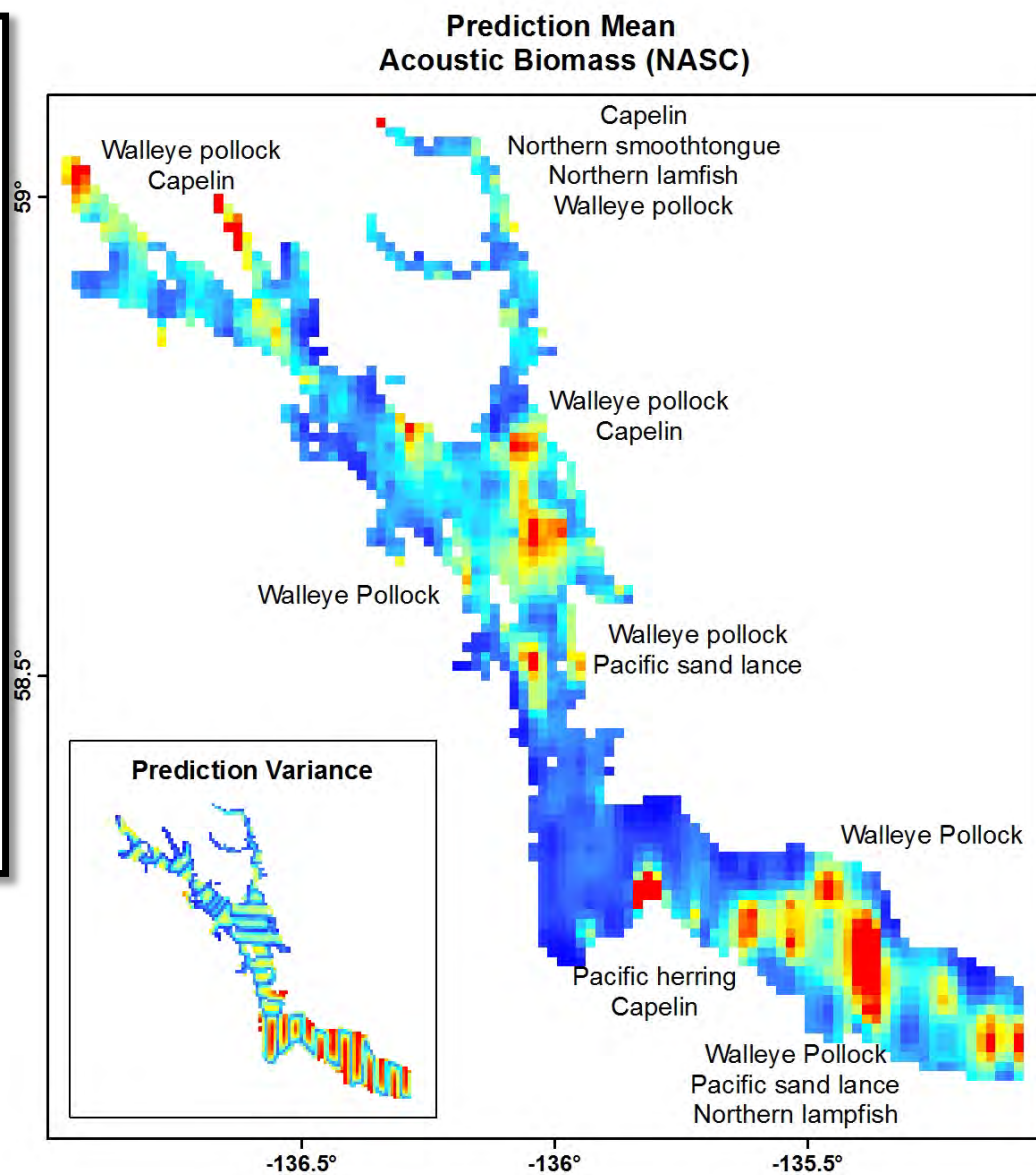
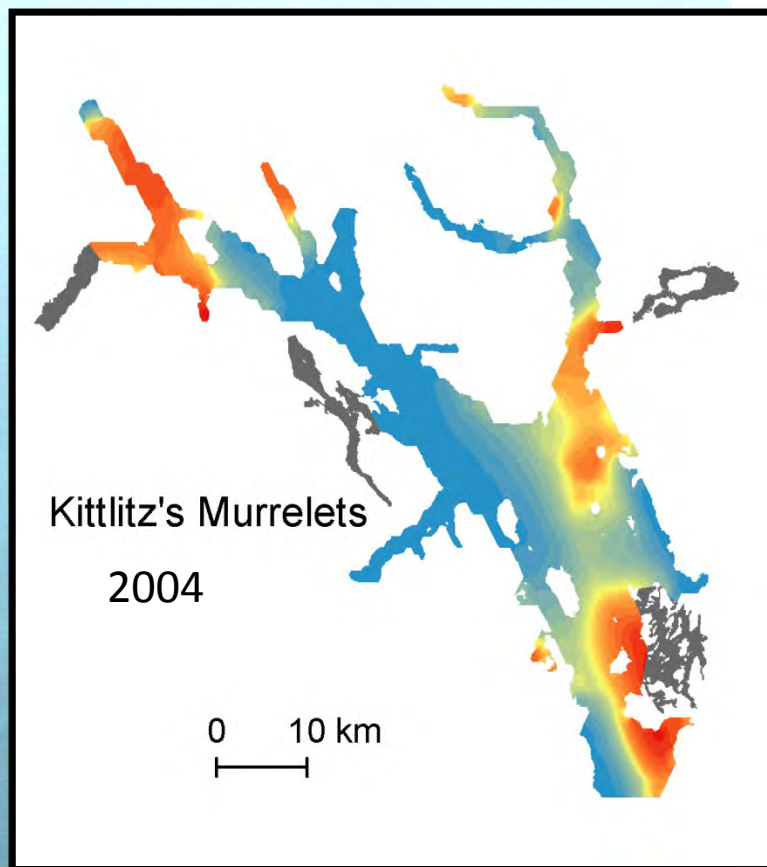
Abundance



Diversity



Distribution of Fish



Harbor Seals

Glacial Ice is Important Haul Out Substrate

- Provides refuge from predation for young seals
- Glacial-born pups have short weaning times
- High fidelity to glacial habitat



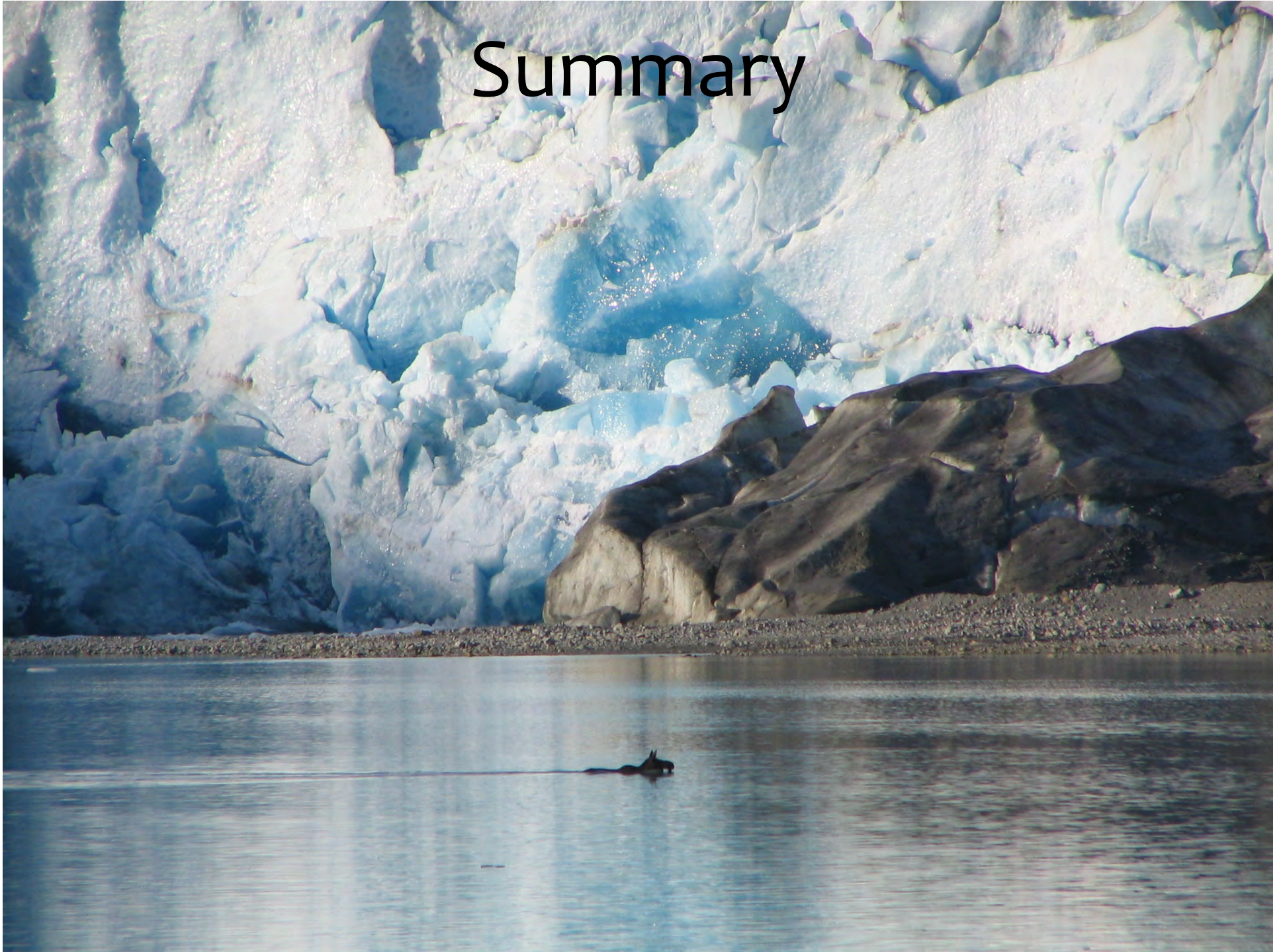
Seabirds Feed at Glacial Fronts

Plunge diving seabirds forage on upwelled crustaceans along the glacier fronts (Greenland, Spitsbergen, Canadian Arctic)

- Concentration of prey through upwelling resulting from subsurface glacier flow
- Mixing caused by calving
- Mortality of zooplankton caused by osmotic shock
- Seasonality coincides with breeding effort in seabirds



Summary

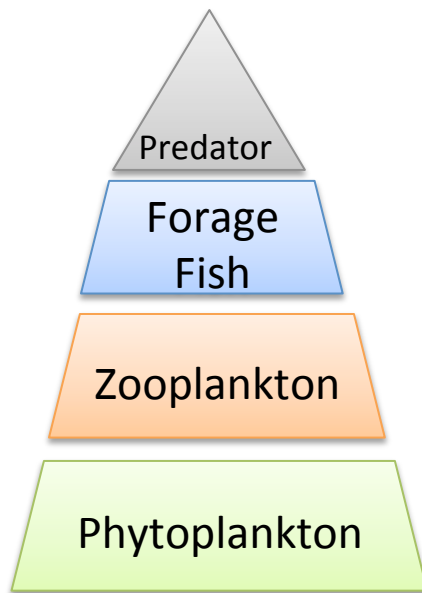


Ecological Patterns in Glacier-Marine Ecosystems

High sediment load limits light availability to phytoplankton

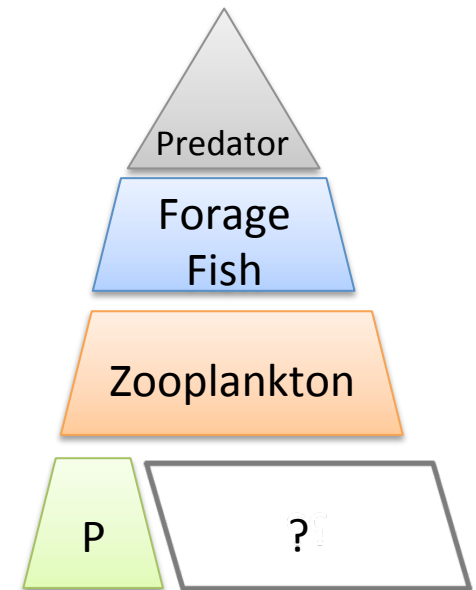


Classical Pelagic Food Web



“...in low carbon/ chlorophyll ecosystems, the available high-quality autotrophic biomass is not sufficient to fuel the classical food web” – Vargas *et al* 2011

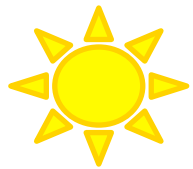
Glacial-Marine Food Web



Ecological Patterns in Glacier-Marine Ecosystems

Absence of photic cue suppresses diel vertical migration

In Clear Water



< 50 m

Depth

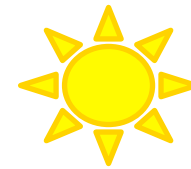
> 100 m

Abundance



Mesopelagic species in near-surface waters during daylight hours

In Sediment-Laden Water



< 50 m

< 50 m

Depth

Abundance

Ecological Patterns in Glacier-Marine Ecosystems

Some visual predators may avoid cold and turbid glacier plumes.

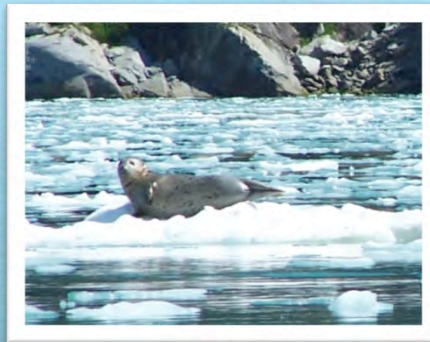
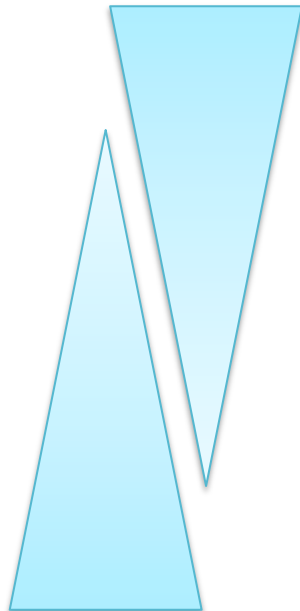
Marine Food Web

Regulated by top-down and/or bottom-up processes

Predator



Environment



Glacial-Marine Food Web

High abundance of nearsurface prey (forage fish, krill) but predators are relatively few.

-notable exceptions:
Harbor Seal
Kittlitz's murrelet
Plunge-diving seabirds

Iron + Nitrate = GOA Production

Iron from freshwater discharge is critical to phytoplankton production



Acknowledgements

John Piatt
Erica Madison
Greg Snedgen
Gary Drew

Mike Litzow
Martin Robards
Marc Romano
Many field crews!

Karen Oakley (USGS)
Shelley Hall (NPS)
Mary Beth Moss (NPS)
Lewis Sharman (NPS)
Lisa Etherington (USGS)
Lisa Eisner (NOAA)
Franz Mueter (UAF)
Dave Irons (USFWS)
Andrew Allyn (USFWS)
Michelle Kissling (USFWS)



